THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR ...Alexandra Kinkaide...

TITLE OF THESIS ...Antecedents of Time Estimation in Childern...

....

DEGREE FOR WHICH THESIS WAS PRESENTED ...M.A....

YEAR THIS DEGREE GRANTED ...1973...

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

THE UNIVERSITY OF ALBERTA

ANTECEDENTS OF TIME ESTIMATION IN CHILDREN

by

©

ALEXANDRA KINKAIDE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF ARTS

DEPARTMENT OF PSYCHOLOGY

EDMONTON, ALBERTA

SPRING, 1973

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Antecedents of Time Estimation in Children", submitted by Alexandra Kinkaide in partial fulfillment of the requirements for the degree of Master of Arts.

To Perry

"mon cher ami"

Abstract

Six hundred (600) _Ss_, ranging from 4 to 26 years of age, were tested to determine: (a) which of the responses antecedent of time estimation (_pars pro toto_, sequence, multiple-sequence) are characteristic for various age groups, (b) how does the accuracy of time estimation improve with increasing chronological age. Two conditions were used for testing: a short (3 min.) simple comedy film (Condition 1) and a 13 min. long film (Condition 2) made up by splicing together two different stories. _Ss_ were required to write down what happened in the film and how long the film was.

Data generally support the hypothesis. _Pars pro toto_ response (a temporal interval is cognized by a single concrete event) is predominant in the younger _Ss_ (4, 5, 6, and 7 years old). The sequence response (characterized by giving sequential order) is predominant in 10 year-old _Ss_. The multiple-sequence response (the realization of several events taking place in sequence) starts to be predominant from 13 years of age. Accuracy of time estimation was increasing chronological age till 15 years in Condition 1. In Condition 2 accuracy increased till age 13 and after that it leveled off.

Acknowledgements

I am very thankful to the principals; Mr.s Anesley, Race, Sharek, Schuller and their staff of Sherman Park Elementary School, Avalon Junior High School, Queen Elizabeth Composite High School and Willow Park School in Leduc for their cooperation in arranging the testing sessions. And thanks to all my subjects for their participation.

Dr. Nelson not only introduced me to the topic but he also remained an interested and patient advisor through every phase of the thesis.

My parents offered support during the times I needed it most.

I am grateful to Peter Herczeg who encouraged me first to pursue a road which, without his understanding and extended help, might have remained only a vague exciting dream.

Table of Contents

List of Tables

Introduction

Time has been thought of and studied from different aspects. Philosophers argue if time is real or only illusionary. Antropologists investigate different ways of regarding time in different cultures. Physicists are concerned with measurement. It is their discoveries which have established and modified many commonly accepted ideas about time. Writers and poets have approached time from other points of view. And, more recently, psychologists have contributed to a vast and diverse literature on time (Osmond, 1972).

Time can be considered as being attached to clocks and calendars and the measurement function they perform. In everyday life, time, more than anything else, refers to numbered records, minutes, hours, days, and years. Familiar time-reckoning involves the continuous counting of sequential time units such as these. This understanding of the word is, however, confined only to a late point in the development of a single concept of time. On this account one must be aware that:

> "Time is not a thing that like an apple, may be perceived. Stimuli and patterns of stimuli occupy physical time; and we react to such stimuli by perception, judgment, comparison, estimates, etc."

and that:

> "...time is a concept, somewhat like the value of pieces of money, that attaches to perception only through a judgmental processes. The ease and apparent immediacy of the temporal judgment in certain cases might be explained as the result of practice, much of it occurring in the first few years of life, in the interpretation in terms of physical time of the numerous alleged temporal cues, (Woodworth, 1960, p. 1235)".

In character it is uniform, unlimited in extension, unlimited in divisibility, and its advance is irreversible (Hallowell, 1939). But these attributes are ideal and abstractions only approached in human adaptation. The question is: How do we come to appreciate these attributes?

Early indicants of time awareness are the infant's ability to adapt to a rhythm of feeding and to meaningful application of devices expressive of time (Fraisse, 1964; Orme, 1969; Sturt, 1925). These occur in childhood (Orme, 1969; Schechter, Symonds, & Bernstein, 1955; Werner, 1948), as well as in primitive man (Nilsson, 1920; Werner, 1948) and only in relation to concrete phenomena. Indications by their nature cannot be numerically grouped together to provide a system for counting or more elaborate reckoning. Werner (1948) points out that "...the primitive temporal concept generally lacks that central focus, that continuity and consistency in counting, which marks a fully abstract quantitatively determined temporal system (p. 185). The outstanding characteristic of time indications then, is that they lack ordinality.

Classically, time inciation refers to a "point" occurring within a duration and not to the duration of some period. The earlier human form of time awareness uses concrete and clearly visible points in reference. Werner says "...time in the primitive sphere, is not so much an abstract measure of order as a moment embedded in the whole concrete activity and social life of the tribe, (Werner, 1948, p. 182)". Piaget (1968) also holds that primitive thought tends towards absolutes on which the primitive happen to be dwelling and thus they fail

to group. Primitive man, and perhaps young children, know only concrete indications of time, if time at all. This phenomenon, Nilsson (1920) calls <u>pars pro toto</u> and this title gives the flavor of the concept. Thus, in primitive man, <u>pars pro toto</u> is represented in rituals based on moon appearances, division of days by dark and sun, etc.

In primitive cultures, (Nilsson, 1920; Schester, et al., 1955; Werner, 1948) time reckoning is tied to indications of cycles made up of elements having an invariant natural order. Somewhere in cultural development, there is explicit and concrete recognition that night and day, seasons of growth and dormancy, and ritual periods such as spring rites form an orderly sequence. Uganda tribesmen, for example, have complicated systems of dividing the day according to a system of concrete work activities. Their system is composed of series of events constituting the day's work; for example, 6:00 a.m. is "milking time", 3:00 p.m. "watering time", 5:00 p.m. "home coming for the cattle", etc. Despite an obvious advance over <u>pars pro toto</u> designations, such concrete time-of-action lack the systematization of continous temporal system. The divisions are based on the dominant events and do not follow each other progressively as a continuum but stand "side by side in isolation, (Werner, 1948, p. 184)". Abstraction plays a minimal role in time reckoning in primitive cultures (Schester, et al., 1955).

Descriptions of human development parallel anthropological data. Developmental literature makes it clear that extended ideas of time require experience. The child's concept of time is based on an ego-

centric concrete mode of experience which tends to develop toward a universal abstract temporal system (Piaget, 1969). Acquisition of the everyday concept of time is a slow process stretching through childhood into adolescence (Bradley, 1947; Doob, 1971; Fraisse, 1964; Orme, 1969; Smythe et al., 1957).

Most studies investigating the development of time awareness unfortunately deal with how time-related words are used, rather than how concrete events are abstracted by the child; nonetheless, they provide valuable information about the development of processes for time indications since they generally agree on the order of the occurrence of certain words although differing somewhat on the exact ages (Orme, 1969). This is not too surprising however, because much of the data has been obtained from special samples of the general population, i.e., children of high average or superior intelligence or those who are defective.

Generally, it may be accepted on the basis of experimental literature that the earliest time cognitions are of special days of the week (like Sunday). This occurs at about the fourth year. Children customarily progress to the day of month by the age of 8 to 9. Consistent with this, young children have difficulties in relating even most recent events and adventures from the near past. Frequently a number of juxtaposed details are given which are quite incoherent (Piaget, 1969). Their memories are not automatically related to one another.

Even though the serial ordering of time is important and is part of the experience of adults it is not innate (Fraisse, 1964;

Sturt, 1925). Apparently the perception of succession precedes the child's grasp of the order of events; this is particularly evident when the child is required to reconstruct events later from unaided memory (Fraisse, 1964). Piaget's experiments (1969) specifically show that young children fail to arrange series of pictures so as to make a story or reconstruct the order in which liquid was taken from a bottle. Such a failure suggests that grammar and vocabulary are not solely responsible for the child's difficulties.

Many experiments (Ames, 1946; Oakden, 1922) bear upon the same point although in a somewhat different way. Ames (1946) notes that young children live only in present till approximately 24 months and from their base in the present expand toward future and past. According to Ames (1946) the word "tomorrow" appears in the 30th month and "yesterday" in the 36th month. However, complete mastery of any one of the time concepts does not happen at once. At first the child responds to a time word, for example, by waiting. Later he can use the word spontaneously and subsequently can answer correctly questions dealing with the concept (Ames, 1946). Fraisse (1964) calls this portion of the development process "expansion of temporal horizon".

Children apparently progress from the concrete experiences of everyday events to more abstract interpretations of events. Fraisse (1963) writes about these changes as follows: "...he adapts to the cycle of everyday long before he knows the special days of the week. Subsequently he conquers time through the organization into sequences of the period of time he has experienced, he orients himself and locates one moment by its relationship to others (p. 262)".

The next step beyond "time indication" is the development of time as a homogeneous and uniform flow. "Time reckoning" is, just as the ability to use time indications, prerequisite for time estimation. The conception of time as an impersonal flow frees a child from a "personal" time predicament and enables estimation of durations. Children know such time through personal activities before they can give the actual clock time. Words which imply duration, in fact, enter their vocabulary by the 36th month (Ames, 1946).

The transition from "personal" to "universal" time is well illustrated by Oakden and Sturt (1922). They asked 4 - 10 year-old children: (a) What time is it for your mother at home now? and (b) What time of day is it in "X" (X being a neighborhood town). While 50% of the answers were correct at age 4, 100% were correct only at age 10. For the second question, 14% of 4 year-olds gave correct responses and 86% of the 10 year-olds. This belated acceptance of the universal time means that the estimation of duration continues to develop relatively late.

It continues to improve into adolescence (Fraisse, 1964; Orme, 1969; Piaget, 1969; Smyth et al., 1957). Ordinarily children have little idea of what a minute or an hour represents even when they have learned to "tell time" on clocks. What age age 8 is impossible, the 11 year-old can do - by that age the children use the time units in appropriate fashion.

What we know about the mechanism of duration estimation is scant. Piaget (1969) suggests that children frequently estimate duration by the work accomplished. On other occasions they rely upon

the number of changes they observed. His hypothesis is based on the development of the concept of space, movement, and velocity, and more generally these are incorporated into his general theory of mental development (Piaget, 1969). According to Piaget, the young child's intellectual representations of time are thoroughly confounded with his representations of space. Children regard each individual movement as having its own "local" time unrelated to those inherent in other movements. With experience they come to know that their judgments are not absolutely reliable and learn to test duration judgments indirectly (Piaget, 1969). In point, Smyth and Goldstone (1957) report on the estimation of a second by children of various ages. They conclude that 6 - 7 year-old children judge duration exclusively on the basis of relative shortness or longness. The authors concluded that the children have not yet learned from the experience because they have not organized their knowledge and acquired an abstract concept of time.

Along different lines, Gilliland and Humphreys (1943) studied clock time estimation of short intervals (9-180 sec.). They compared estimates of 5th graders with those made by adults; adults were 15-18% more accurate. Smyth and Goldstone (1957) found there is a great degree of variability in estimating 1 sec. intervals by children 6 to 8 which progressively decreases to age 14 when it reaches the same accuracy as in adults. Orme (1967) reported that 16 year-old group approached adult estimation. The apparent disagreement on the exact age may be partly because of differences in sample selection, and/or by different intervals and methods of estimations.

It has been suggested (Foester, 1969; Fraisse, 1964; Fress, 1962) that children's slow development of the appreciation of duration is, at least partly, due to insufficient educational attention. Such allegations are supported by a study reported by Fraisse (1964) in which 7 year-old children were shaped to evaluate 30 sec. intervals by being told if their estimates were "too long" or "too short". After three weeks of such training the children improved by about 30%, and the author concludes that "it is essentially the training which is lacking (p. 238)".

Others, recognizing limits, hold that other aspects of the time concept cannot be greatly accelerated. Farrell's (1953) research with 5 - 7 year-old children indicate that at some ages certain concepts cannot be comprehended even by children with high IQs. Because of the lack of extensive and purposive research into this problem no final conclusions can be drawn. Considering, however, the developmental nature of the time concept it may be expected to be related to individual differences in mental development as well as to the amount of practice.

More specifically, several authors have found a positive correlation between the comprehension of time words and scores on the intelligence tests. Lovell et al., (1960) in an experiment based on Piaget's observations, compared performances of Ss with above average IQs to those selected from a school for educationally subnormal children, and found 16 - 17 year-old subnormal Ss perform at a level comparable to approximately 9 year-old normal Ss. Smyth and Goldstone (1957) working with 14 year-old boys of superior and average IQ found no

differences between their estimation of 1 sec. Nonetheless further inquiries into such relationships are needed before conclusions can be reached, especially since research with young children has been neglected.

The investigations to be reported delineate developmental events related to the acquisition of temporal concepts by the child. The purpose was to study how experiences of concrete events accompany development of time related ideas. The cultural antecedents to "time measurement" described by Nilsson as "time indication" and "time reckoning" suggest developmental parallels that might be studied. One should, on this basis, expect development of a pars pro toto type of awareness followed by sensitivity to sequential components in isolation and inter-relation.

Fortunately pilot work (Appendix A) has made the possibility of hypothesizing ontological parallels possible. Pars pro toto analyses of film sequences (i.e., the whole system of temporal patterns is represented by a single event or condition) are characteristic of young children. Also, children relate sequential components of films before they notice the presence of multiple ontological components.

Derived partially from the above mentioned pilot study the following hypotheses were formulated:

(a) The earliest social concern with time takes a pars pro toto form. Such responses will be characteristic of 4 - 6 year-old children.

(b) The second stage will be characterized by descriptions of ordered event sequences (time indication processes). These will be

predominant in children of the next age, i.e., a 7 - 10 year age group.

(c) The third stage of development will be marked by an ability to describe events in multiple-sequential order. This accomplishment will be achieved by 12 years of age.

Paralleling the meaningful expressions of temporal relationships in concrete events one might expect improvement in the understanding of abstract expressions of time. More specifically, we may expect on the basis of previous literature that:

(d) estimation of film duration in temporal units will improve with age, and

(e) the ability to estimate time will plateau at 15 years.

Finally, assuming the validity of evidence that greater accuracy in time estimation distinguishes children of high IQ from those of low IQ, it is predicted that children of higher IQ will be advanced in expression of temporal relationship in concrete events in comparison to children of lower IQ having the same chronological age. More specifically, it is predicted that:

(f) a reliable difference in the accuracy of time estimation and the frequencies of particular responses will characterize <u>S</u>s of high IQ from those of low IQ.

Method

Subjects

Six hundred (600) Ss ranging from 4 to 27 years of age served. All came from Edmonton kindergartens, Junior High School, Compository High School, and Sherwood Elementary School, and adults were first year students from the University of Alberta. Details are given in Table 1. IQ measures based upon Lorge Thorndyke's group test (1967) were obtained from the school records.

Testing Materials

A super 8 mm. film projector (Bell & Howell) was used with projection screens installed in classrooms. Stimuli were provided by two silent 8 mm. films produced prior to 1940 distributed by Ken Films Inc. Each sequence had action and humor designed to appeal to the age range of Ss.

The first short film (Condition 1) called "Glad Rages to Riches" featured Shirley Temple and lasted 3 minutes. The second film (Condition 2) was made up of two parts, a cowboy action-drama featuring John Wayne and the comedy sequence represented in Condition 1. This film version consisted of 4 successive sequences, i.e., 5 min. of the cowboy story followed by 1.5 min. of the other story, followed by a 5 min. cowboy and 1.5 min. comedy.

Procedure

Ss were tested within a one month period in classroom groups ranging from 5 to 25 persons. Only one film was projected to each

Table 1

The Distribution of Ss for Conditions 1 and 2.

CONDITION 1

Grade	Mean Age	Total No. of Ss	No. of Female Ss	No. of Male Ss
Pre-schoolers	4.6	25	12	13
1	5.7	25	10	15
2	6.8	25	13	12
3	7.8	25	13	12
4	8.9	25	14	11
5	9.8	25	9	16
6	10.8	25	12	13
7	11.9	25	13	12
8	12.9	25	15	10
9	13.7	25	16	9
10	14.9	25	16	9
Univ. Students	18.2	25	12	13

CONDITION 2

Pre-schoolers	4.7	25	16	9
1	5.6	25	15	10
2	6.8	25	13	12
3	7.9	25	15	10
4	8.9	25	16	9
5	9.9	25	10	15
6	10.9	25	12	13
7	11.8	25	16	9
8	12.7	25	12	13
9	13.8	25	16	9
10	15.2	25	15	10
Univ. Students	17.9	25	11	14

group. The following instructions were given: "I will show you a film now. I want you to pay close attention so you can tell me later what it was all about and all that happened". Immediately after the film ended the Ss older than 8 years were given the following questions in printed form: (a) How long was the film? and (b) What was the film about? Ss were encouraged to write down as much as they could recall. They were also required to write their age, name grade, and sex.

Younger Ss were shown the film in the same fashion but groups were restricted in size to 5 persons. The same data were obtained through oral questioning. All Ss seeing the short comedy film were asked how long the film lasted.

Evaluation of Response

All verbal and written responses were classified into three categories:

1. No Response - no descriptive material elicited through questioning this S's statement that he can remember nothing of the film story.

2. Pars pro toto - concrete descriptions of the single unrelated events occurring in the film. Shortness or longness is not the relevant dimension of the PPT response although ordinarily PPT responses are shorter than other types. Three PPT examples follow:

> "It was about a man who was angry at an actor".
>
> "The movie was about cowboys and Indians. When the Indians caught the cowboys they threw them into a big fire".
>
> "Cowboys and Indians and little kids running around with just their pants on".

3. <u>Sequence Response</u> - properly ordered report of events from the film. An example from the short film is:

> "She was in a studio. First a little girl was powdering her face. Then a boy came in she didn't like. Then another boy was in another room when another girl was there they hugged each other. Then they showed some boys that came in and were fighting. The little girl wanted to go to see what was going on but the boy was holding her."

The split film provided a special problem of interpretation. In case of the split film, the description was judged to be a sequential response only when there was no indication that the S had recognized that there were two independent stories shown, i.e., Ss meeting the "sequence" criterion had events in the proper order without realizing that the parts were otherwise related. An example is:

> "At the beginning a run away stage was being chased by the U.S. Calvary. When they caught it they found that the U.S. paymaster was killed by Indians. After the funeral they went after the Indians. When they saw the Indian camp and they saw men selling rifles to Indians. The Indians killed them and took all the rifles. Then the calvary got ready to charge. Then these children got worried. When the show started the calvary charged and stampeded the horses and took them so the Indians couldn't ride them. The the show was over."

> "It was about cowboys and Indians fighting and a guy got an arrow through his back and little guys were kissing."

4. <u>Multiple-Sequence Response</u> - is an additional category appropriate only with Condition 2 data. This classification required indication that the two different parts of film were recognized as forming two different stories. Three examples follow:

> "The movie was about a raid by the Indians and the calvary was trying to stop them. The next movie was about young children about 3, 4, or 5 doing a love scene."

"Well, there were two parts. There was a war between the Indians and the white men. The white men won. There was a love story in which Shirley Temple starred. The bad guy wanted her to marry him. But she loved another. The bad guy tried to take her away, but the police caught him. Then the two lovers lived happily ever after."

"The movie was a western showing which (I think) Calvary and the Indians, and how they went about conquering them. The second movie was briefly about how small children act sometimes in a grown up way such as their love making and the way one boy got jealous over the little girl when the other boy and her were together."

Care was taken not to confuse *pars pro toto* response with multisequential response for older *S*s. Some older *S*s gave brief summary statements interpretating the film but also showed awareness of inter-related details.

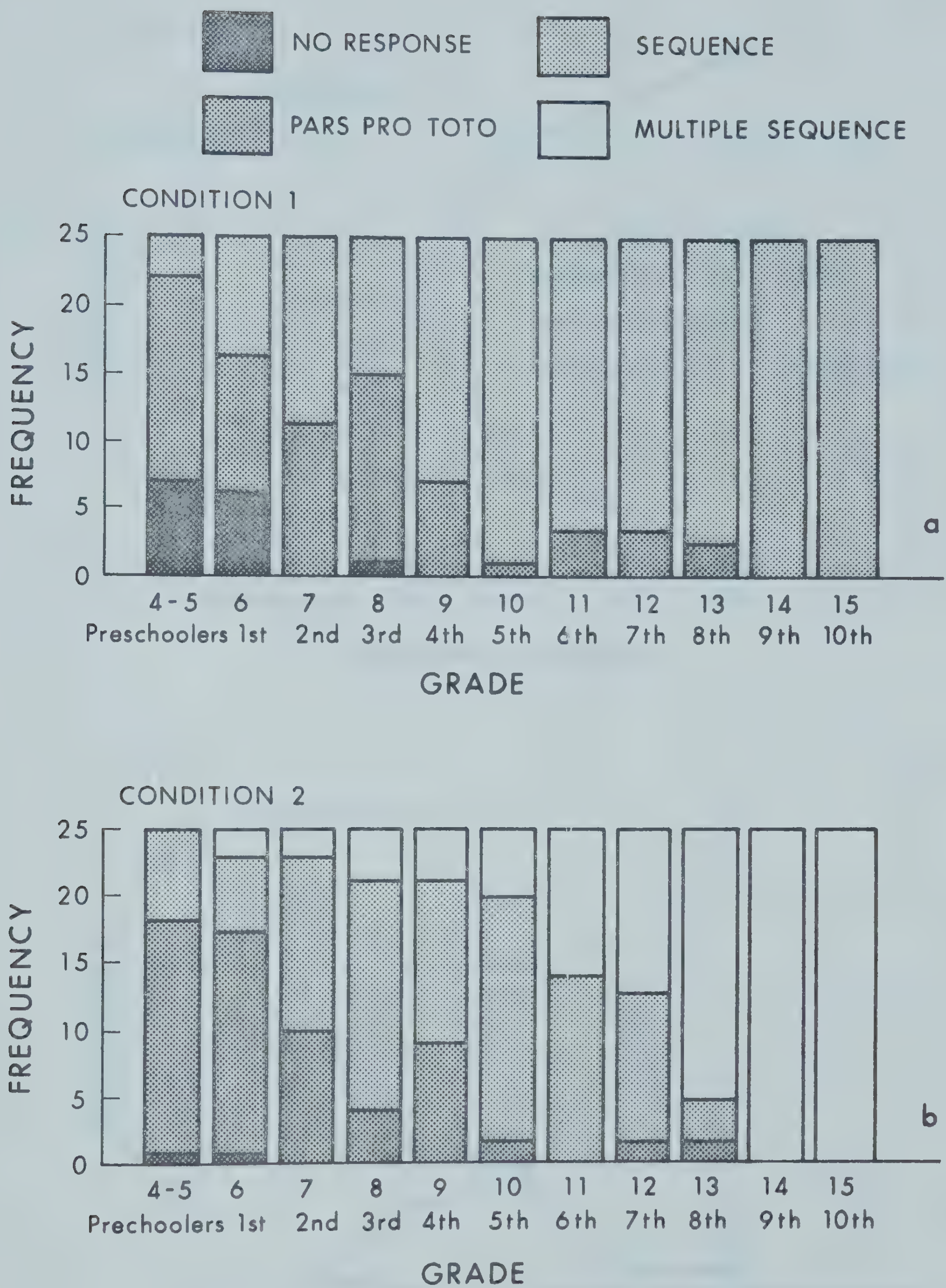

Figure 1: The Distribution of "No Response", Pars Pro Toto, and Multiple Responses Across 11 Age Groups for Condition 1 and 2.

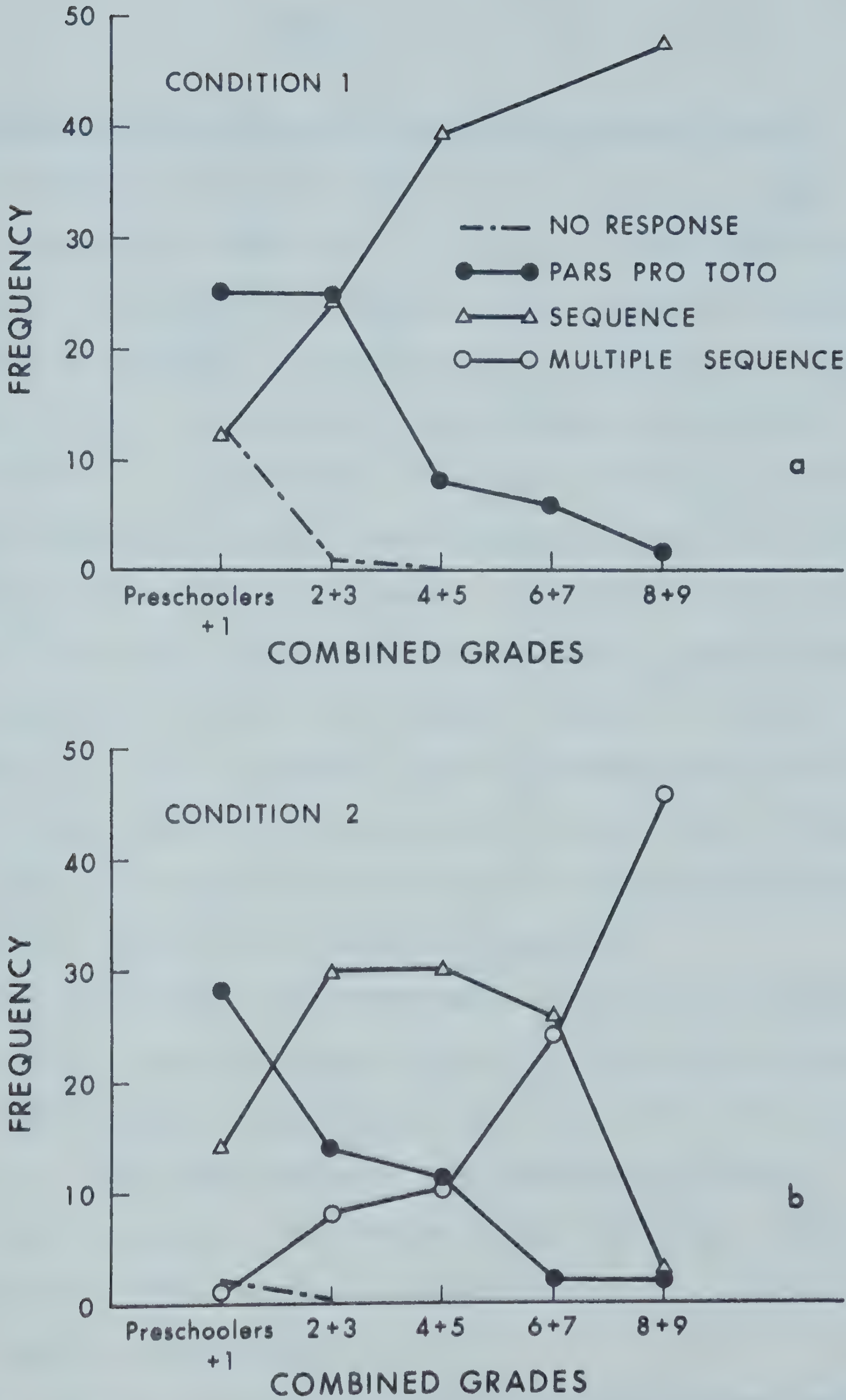

Figure 2: Frequency Distribution of Responses for Groups Composed of Several Grades.

Results

Frequency distributions of the particular responses across age for Conditions 1 and 2 are illustrated in Figure 1a, b, respectively. Notice that results are in a direction favoring Hypotheses A, B, and C. A Chi-square test (Edwards, 1972) between the concerned age groups for Condition 1 indicates reliable differences ($\chi^2 = 54.74$, $df = 8$, $p < .01$). Chi-square tests were also used for comparisons shown in Table 2. For Condition 1, significant differences ($p < 0.01$) were found between the youngest group (preschoolers and first graders) and the Ss attending 2nd and 3rd grades. The latter group also differed ($p < .01$) from the 4th and 5th grader children. From the results it can be seen that by age 10 the "sequence" response is used by a majority of Ss. The "no response" category disappears almost entirely by the 6th year. Data were also analyzed at the year level in order to see whether there was evidence for a sharp change suggestive of a critical age. Results are inconclusive (Appendix B).

The results obtained from experimental Condition 2 are summarized in Table 2. Again, data were analyzed by applying the Chi-square test. The χ^2 between all age groups is significant ($\chi^2 = 41.84$, $df = 12$, $p < .01$). The group composed of preschoolers and 1st graders differ significantly ($p < .01$) from the 2nd and 3rd graders. Also 4th and 5th graders differ from the 6th and 7th graders ($p < .01$), and the latter from 8th and 9th graders ($p < .01$).

The frequency distribution of responses for the analyzed groups are shown in Figure 2a and b.

Table 2

Frequencies of Responses for Combined Groups Analyzed by Chi-Square Test

	CONDITION 1		CONDITION 2	
Compared Grades	Degrees of Freedom	Chi-Square	Degrees of Freedom	Chi-Square
Preschoolers, & 1st, 2nd, & 3rd	2	14.29**	3	20.91**
2nd & 3rd vs. 4th & 5th	2	14.67**	3	.38
4th & 5th vs. 6th & 7th	2	.33	3	12.81**
6th & 7th vs. 8th & 9th	2	2.17	3	24.40**

** $p < .01$

* $p < .05$

The actual distribution of time estimations is shown in Table 3. Looking at this table, one can see that time estimations are unevenly distributed for grades 6 and 10, i.e., preferences for numbers "15" and "20" are apparent. Bias toward choice of common numbers introjects a spurious factor into the results. This will be returned to in the discussion section again.

To make data comparable, each S's time estimate was expressed as an error of estimation by subtracting the real time from the estimated time. An analysis of variance performed on error data from Condition 1 data yielded a significant Grades main effect ($F = 5.27$, $df = 9/240$, $p < .01$). (See Appendix C). A more detailed breakdown of differences is provided by Scheffe's multi-comparison test (Edwards, 1972) of the group means. This test reveals that the mean time estimation errors for grades are significantly different for all errors for grades 7 excepting 5 and 6. The mean time error in relation to chronological age is illustrated in Figure 3a. Notice that the mean time error steadily declines with increasing age.

An analysis of variance performed on error data from Condition 2 (see Appendix D), yielded a significant Grades main effect, ($F = 8.80$, $df = 6/168$, $p < .01$). Using Scheffe's test, significant differences are evident between the time estimation errors of grades 4 and 8, 4 and 9, grades 6 and 8, grades 6 and 9, and finally, between the grades of 7 and 8. The time estimations of the young adults however were not significantly different from the 15 year-olds for either condition. Figure 3 illustrates the decreasing estimation error with increasing age. Inspection shows that at age 13, the error is lowest

Table 3

The Frequency Distribution of Time Estimations

Grades

Time Estimated	5th	6th	7th	8th	9th	10th
> 10	1	1	2	0	0	1
10	0	0	0	0	3	2
11	0	0	0	0	0	0
12	0	0	1	3	3	1
(13)	2	0	4	11	2	0
14	0	0	0	1	0	0
15	10	5	1	5	13	8
16	0	0	0	1	1	0
17	1	2	2	2	0	0
18	0	1	0	1	0	1
20	5	13	8	0	2	9
< 25	2	4	4	0	0	1

Figure 3: Variation of Time Error with Grade.

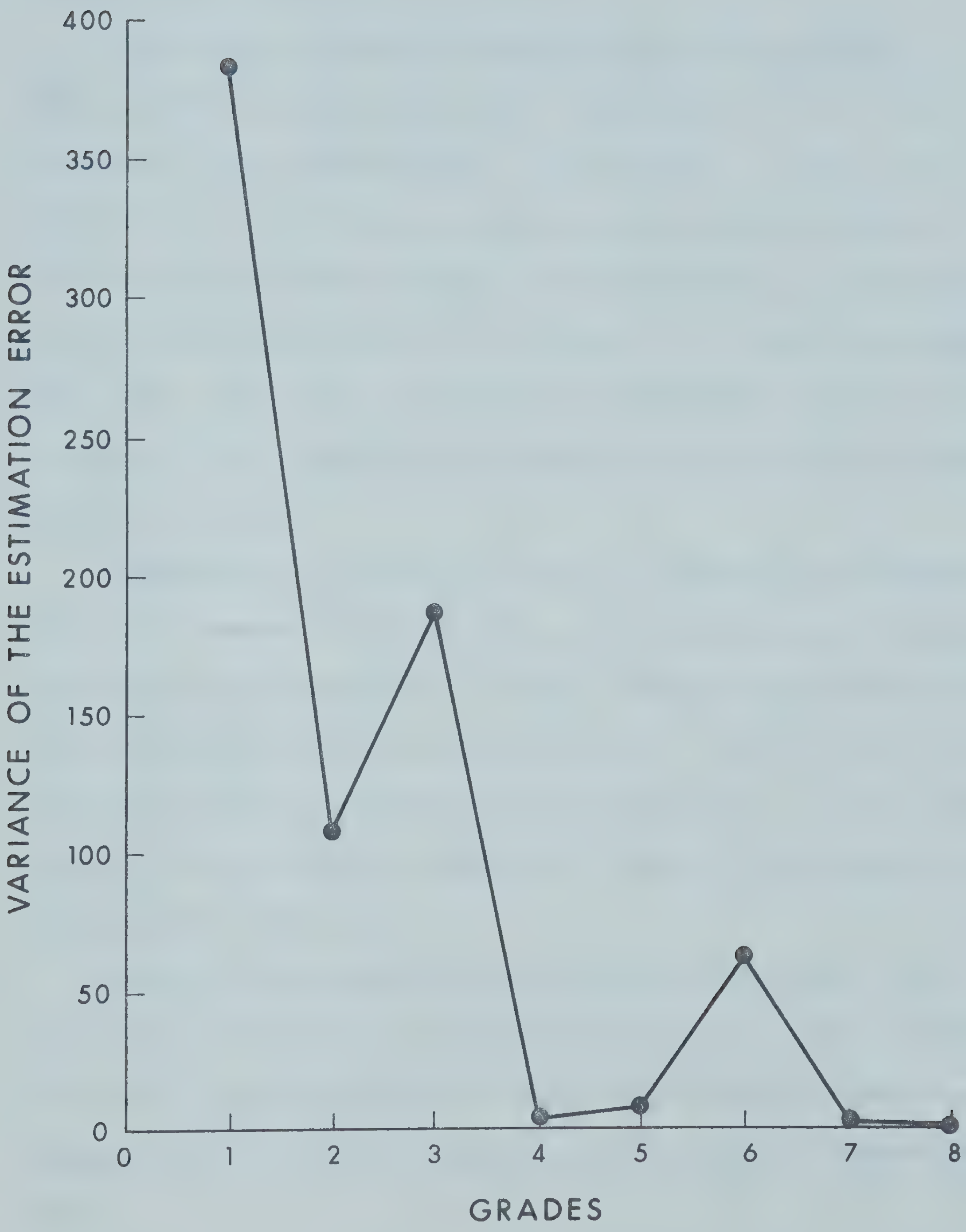

Figure 4: Variance of the Means of Time Estimation Error for the Short Film.

but after this age error again increases, although, again, the increase is not statistically reliable.

The variance of the time estimation error for Condition 1 (Figure 4) differs significantly (x^2 = 469.2783, df = 2, p < .01) due mainly to the large variances in the grades 1, 2, and 3. The significance of variability may seem to pose a question about the validity of the previous analysis. While homogeneity is admittedly a basic assumption of analysis of variance, it is a weak requirement (Box, 1953): the F test is a robust test relatively insensitive to violations of the assumptions of normality of distribution and homogenuity of variance.

Turning now to correlations obtained relating time estimation error and IQ scores for the 4th, 5th, and 6th grades, we find these were largely inconsequential. The only finding of consequences seems to be a significant negative correlaltion (r = -.267, df = 74, p < .05) between error of estimate and IQ for Condition 1. Only a small portion of children from the sample with higher IQ's were more accurate than those with lower IQ's.

Along much the same lines, Ss belonging to the highest quartiles of the IQ scores were compared to those of the lowest quartile. A Chi-square test was applied to compare the frequency of their reresponses but significant differences were not found for either condition.

Discussion

We will try to show how our findings fit within what is already known. But in all cases, we must recognize inherent difficulties of doing so. A statement made by Heisenberg: "We must remember that what we observe is not nature itself, but nature exposed to our methods of questioning" seems particularly appropriate here.

The decision to investigate cognitive processes occurring antecedent to time estimation takes one into an area of complex problems falling in an as yet "unmapped" psychological space. Lacking conceptual guidelines the present study makes ineffective contact with the body of existing research dealing with time perception. Methodologically unique, our stimuli were sequential, meaningful, concrete, and 3 or 13 minutes in length. Developmental literature, in contrast, centers around perception of brief single episodes either empty or filled with meaningless physical input. Our extensive sampling of age groups is also atypical. Data is more often than not incomplete across childhood, short, single studies being the rule. The method employed to collect responses is uncommon too. Many and various methods have been employed and while these are often difficult to compare, most interpret elementary time perception and do not allow for generalization to real situations encountered.

Moving to the theoretical level, we find that it is thin with the exception of Piaget, Fraisse and Sturt who, however, again direct themselves to problems independent of ours. Developmental literature dealing with temporal phenomena and memory approach the problems from

many discrete directions without uncovering a consistent underlying mechanism in development.

Nilsson's descriptive theory of cultural development bolstered with Werner's observations of primitive man, provided working hypothesis for us, our interest being in redimentary organization of temporal experience. Consistent with expectation, we find that as children get older their awareness of the complexities of change expands toward mastery of an adult use of time. Results from our study are in general agreement with pilot work based upon Nilsson's descriptive theory (Nelson et al., 1966) both indicating that aspects of pre-temporal awareness are measurable. Moreover, the characteristics which children exhibit during different stages of their individual development follow pre-temporal evaluations in primitive cultures described by anthropologists. More specifically:

(a) _Pars pro toto_ reports called "the earliest social concern with time in primitive cultures" Nilsson (1920) are found in the youngest children and are pervasive till age 8. In preschoolers, _pars pro toto_ occurred in almost half the cases, the remainder falling predominantly in the "no response" category. "No response" disappears by the first grade. We will not attempt to explain the basis of the "no response" since it is not certain whether this can be meaningfully attributed to memory, attentional, and emotional factors or, alternatively, to a lack of cognitive integration.

Piaget's data indicates that children who would exhibit _pars pro toto_ responses are usually not very efficient in counting, suggesting that cognitive limitations play a role. The observation of

Nilsson (1920) that "counting is abstract, the primitive man clings to the concrete phenomena of the outer world (p. 355)", also offers insight into children of early age.

Other indirect evidence pointing to the presence of cognitive factors is that of Sturt's (1925). In her research into the usage of time related words she concluded that "...in the records of the children's speech or answers there is little to suggest that they are able to arrange events past or future in a definite series (p. 123)". The records to which she refers would be classified as pars pro toto representations of time in our framework. For example, when she asked a child what the season is and he answers "summer because it is hot (Sturt, 1925)", the child represents summer as a single type of weather. In Sturt's work we have another instance in which concrete easily distinguishable features are given as an alternative to description of a series of events or interdependent changes. (A more complex response in this context might emphasize the relation of weather to other personal and social activities.)

(b) Next in level of complexity we have the sequence response which, as defined in the present study, is most predominant in 10 year-olds. For children at this stage, the day is made up by events following one another. Even though the child knows how to read the clock, he gives discrete responses indicating limitations of time awareness, e.g., "it is 6 o'clock because it is dinner time (Sturt, 1925)". The day is conveyed as a line of discrete activities and the past is represented by a simple progression of images (Sturt, 1925). Nonetheless, we must not omit to notice that this stage is a major advancement

because it requires an explicit recognition of past and future in addition reasoning and conscious arrangement.

Such identification of sequences parallels the ability to indicate the day of the month. In this respect it seems to approach a single concept of time but care should be taken to separate recognition of sequential arrangement from the understanding of relationship between events. A child correctly reporting a serial event can be just as bound by concrete-discrete perceptions and representations as one giving a *pars pro toto* form, when presented with two inter-mixed stories. Children who have not progressed beyond this level can only relate as one single episode; they do not realize that two independent dramas are developing.

(c) *A multiple-sequence response* is the final step in preparation for an understanding of the adult concept of time. The child at this level relates the proper order and in addition shows that he or she understands that events are related by something other than a simple physical sequential order. Such a child demonstrates knowledge that he is aware that in any given time there are unrelated events in process. This response becomes predominant by age 13.[1]

Since our interpretation of these stages is to be made within the human context, we will turn our attention to another facet of investigation. We found a lack of relationship between mental age and type of report. This result is understandable in light of the limited ranges of IQ used and probably occurred because the difference between the mental ages in our sample were not large enough. Our study probably did not provide an optimal condition for testing the chronological

limits of any of the stages. For example, if severely limited children were used they might fail to reach the multiple sequential stage of response because severe retardates are known to have problems with processing more than one stimuli at a given time (Zeaman, 1965).

Acknowledging the failure of children to understand the concept of historical progression through formal instructions (Friedman et al., 1945; Fress, 1962), it is possible that the stages of development which we have been discussing may have importance for education. Certainly, some of the particulars reported by Sturt (1925) for the experiments dealing with children's understanding of history seem understandable in our framework. Problems associated with understanding the progression of history and chronology are reported to persist till about 13 years old. Thus, Sturt (1925) found that the ability to arrange historical figures into proper chronological order increases from 8 to 13 years, i.e., children cannot perform this task efficiently before they can produce and hence presumably recognize the existence of sequential order. This fact corresponds with our data.

Another experiment (Sturt, 1925), in which she used "temporal completion" test, showed that children younger than 13 years seem to have "lumped all historical periods together giving them general attributes (p. 64)". Again such findings are consistent with children's inability to recognize multi-sequence phenomena since multiple sequence response becomes predominant at this age.

The problem of memory is traditionally linked with time perception. Distinctions between the present, past and future would not exist without time perception because memory is by definition a

remembrance of past events (Nomann, 1968). Unfortunately, literature dealing with this issue is rather slim and difficult to summarize so as to bear upon our data in any productive way.[2]

It may suffice to say that in the present study interest is in the quality of free-recall and classification of answers into categories. The different stages which we were able to separate indicate that although they may be part of more general cognitive development and memory, their development is important on its own as part of the processes underlying the different awareness of time or as an indicator of that process.

Parallels between the development of concepts of time in children and characteristics of time concept in some primitive cultures support this interpretation. While such correspondence may be accidental or superficial on the basis of the type of evidence being reported the correlation between accuracy of time estimations and the type of report given are suggestive of a pervasive mechanism for dealing with events which are temporally spread out.

Time estimation data confirm that accuracy develops slowly through childhood without any dramatic improvements. No ages seem to be particularly decisive for this task. The length and the content or the complexity of the presented films proved to be important for the accuracy of time estimation. Most understanding in this respect is the consistent over-estimation for all tested ages under both conditions. These findings are in agreement with the previous research by Fraisse and Montmolin (1952) using short films and Mussatti (1931) and Mayers (1916) asking about the time estimation of a

baseball game. Over-estimation seems to be connected with the physical inactivity of the spectator and to the novelty of the observed events (Fraisse, 1964).

These particular findings fit into Ornstein's (1969) "storage size of information theory" fairly well because he suggests that "...duration depends on the size of the storage space for the information of a given interval. The size of the storage space would depend on two factors: the amount of information or number of occurrences in the interval which react awareness and the way in which that information was 'chunked' and stored. The same amount of information might subtend different storage sizes depending on how efficiently it was coded (p. 104-105)". On an experimental level, Ornstein showed that when a person is in a situation in which he performs familiar tasks "automatically" to some stimuli and thus is aware of less stimuli, he experiences the duration as a short one.

In the present experiment Ss were watching unfamiliar films and probably paid more attention and were thus aware of more stimuli. Presuming a relationship between the number of elements present in S's awareness and the duration experience, they experienced a longer duration than would be the case if the film would have been familiar. In the case of the split film, which gives the most difficult data to interpret with regard to time estimation, the Ss could be receiving more stimuli because of the unexpected nature of the film. It would be instructive to see if a film of the same length but of less complex nature (no "flashbacks") would indeed yield shorter estimations. Such a study is underway.

In the youngest Ss time estimations supported previous research Sturt (1925), in terms of efficiency of using time units. Looking at the distribution of variance, age 9 seems to be critical for the ability to use time units meaningfully. The change in the variance between the children younger than 9 and the older ones can be seen in Figure 4. Incidentally, a reliable relationship was found between time estimation error, chronological age, and mental age for the short film, suggesting that the particular task experience and general mental development are important.

As said above, results of the split film are less clear. Neither the chronological age nor the mental age appear to be an important factor. For indeed there is not even a significant change to be found between the 9 year-old and the 15 year-old counterparts. Looking at the Figure, one can see estimation improving till age 13 and after that it stagnates. Possibly the unexpected results are attributable to two possible factors. First, since the nature of the film had to be relevant and understandable to very young children, the older Ss may have found the task boring and experienced it as being "talked down to". Ornstein (1969) says that in boring situations, Ss are "forced to attend to more of the stimulus array than they normally would" and this effort can cause a lengthening of duration experience. Personal observations of our older Ss support this possibility.

A second explanation may be inferred from Table 3. Notice that there is a sudden shift in using blocks of time units. While research on number preferences is restricted to adult populations,

there is an indication that it may correlate with development of temporal sophistication. This, however, does not explain why a plateau far short of proficiency would be shown. In the absence of other data one must only conclude that yet another complex process is in action.

Psychological time, if there is such a single thing, is subjective as opposed to physical time as measured by instruments. It does not seem to be guided by any single "law". The perception of duration is influenced not only by the amount of practice but also by the nature of the content, by the physical environment, by person's personality (Doob, 1971; Fraisse, 1964; Orme, 1969). It has been said that "learning and applying a concept appropriately necessitates an ability to discriminate, to understand, and to use both its relevant stimulus features and its rule (Bourne, 1970)". The concept of time similarly may be acquired through childhood with recognizable stages in the ability to discriminate and understand the various features of relationships in a given time interval. Surely in children we see that adaptation of standard time units improves accuracy of estimation. In the case of relatively simple stimuli, as presented by the short film, accuracy seems to be a function of the general mental development. With more complex stimuli such a relationship does not hold after a certain age.

References

Ames, L.B. The development of the sense of time in the young child. Journal of Genetic Psychology, 1946, 68, 97.

Belmont, J.M. Perceptual short-term memory in children. Journal of Experimental Child Psychology, 1971, 5, 114.

Bourne, L.E., and O'Banion, K. Conceptual rule learning and chronological age. Program on concept learning. Report No. 11. Institute for the Study of Intellectual Behavior, May, 1970.

Box, C.E.P. Non-normality and tests on variances. Biometrika, 1953, 40, 318.

Bradley, N.C. The growth of the knowledge of time in children of school age. British Journal of Psychology, 1947, 38, 67.

Calfee, R.C. Short-term recognition memory in children. Child Development, 1970, 41, 145.

Cambel, B.A. Ontogeny of memory. Psychological Review, 1972, 79, 215.

Doob, L.W. Patterning of Time. London: Yale University Press, 1971.

Edwards, A.L. Experimental Design in Psychological Research. New York: Holt, Rinehart and Winston, Inc., 1972.

Farrell, M. Understanding of time relations of five-, six-, and seven-year-old children of high IQ. Journal of Educational Psychology, 1953, 46, 587.

Flavell, J.H. Concept development. Manual of Child Psychology, P.H. Mussen (Ed.). New York: John Wiley and Sons, Inc., Vol. II, 1970.

Foester, L.M. The development of time sense and chronology of culturally disadvantaged children. _Dissertation Abstracts_, 1969, _29_, 3321-2A.

Fraisse, P. _The Psychology of Time_. London: Eyre and Spottiswoode, 1964.

Fress, P. Adaptation of man to time. _Psychological Abstracts_, 1962, _36_, No. 2BCF43.

Friedman, K.C., and Marti, V.A. A time comprehension test. _Journal of Educational Research_, 1945, _39_, 62.

Gilliland, A.R., and Humphreys, D.W. Age, sex, method and interval as variables in time estimation. _Journal of Genetic Psychology_, 1943, _63_, 123.

Hallowell, A.I. Temporal orientation in western civilization and in a preliterate society. _American Anthropologist_, 1939, _2_, 647.

Hansen, D.N. Short-term memory and presentation rates with young children. _Psychonomic Science_, 1965, _3_, 253.

Klugman, S.F. Memory for position among children, as measured by serial reproduction. _British Journal of Psychology_, 1944, _35_, 17.

Lorge Thorndyke Group Test. Ontario: G. Nelson Sons Canada Ltd., 1967.

Lovell, K., and Slater, A. The growth of the concept of time in children of school age. _British Journal of Psychology_, 1947, _38_, 67.

Mayers, G. Incidental perception. _Journal of Experimental Psychology_, 1916, _1_, 339.

Neimark, E., Slotnick, N.S., and Ulrich, T. Development of memorization strategies. Developmental Psychology, 1971, 5, 433.

Nelson, T.M. Pars pro toto in children, unpublished, 1966.

Nilsson, P.M. Primitive Time Reckoning. Oxford: Oxford University Press, 1920.

Norman, D.A. Toward a theory of memory and attention. Psychological Review, 1968, 75, 522.

Oakden, E.C., and Sturt, M. The development of the knowledge of time in children. Journal of British Psychology, 1922, 12, 309.

Orme, J.E. Time, Experience and Behavior. London: Iliffe Books Ltd., 1969.

Ornstein, R.E. On the Experience of Time. Harmonswoth: Penguin Books Ltd., 1969.

Osmond, H. Introduction: The future of time, (Ed.) by H. Yaker, H. Osmond and F. Cheek. New York: Anchor Books Doubleday and Company, Inc., 1972.

Piaget, J. The Chil's Conception of Time. A.J. Pomeraus (trans.) New York, Basic Books, Inc. Publishers, 1969.

Rossi, S. Developmental shifts in verbal recall between mental ages two and five. Child Development, 1971, 42, 333.

Schechter, D.E., Symonds, M., and Bernstein, I. Development of concept of time in children. Journal of Mental Disease, 1955, 21. 301.

Siegel, L.S. The sequence of development of certain number concepts in preschool children. Developmental Psychology, 1971, 5, 357.

Small, M.Y., and Lucas, M. Children's performance in simple and successive reversal concept identification. Journal of Experimental Child Psychology, 1971, 12, 405.

Smyth, E.J., and Goldstone, S. The time sense: a normative genetic study of the development of time perception. Perceptual Motor Skills, 1957, 7, 49.

Springer, D. Development in young children of understanding of time and the clock. Journal of Genetic Psychology, 1952, 80, 83.

Sturt, M. The Psychology of Time. New York: Harcourt, Brace and Company, Inc., 1925.

Werner, H. Comparative Psychology and Mental Development. New York: International Universities Press, Inc., 1948.

Woodworth, R.S., and Scholosberg, H. Experimental Psychology. New York: Henry Holt and Company, 1960.

Zeaman, D. Learning processes of the mentally retarded. The Bio-Social Basis of Mental Retardation, (Ed.) by S.F. Osler and R.E. Cooke. Baltimore: The Johns Hopkins Press, 1965.

Footnotes

1. In everyday life multiple sequence awareness is well illustrated in the ordinary farmer's almanac.

2. Various aspects of memory, like memorization processes (Small & Lucas, 1971), concept of seriation (Siegel, 1972), or investigation of ontogeny of memory (Cambel, 1972) etc., have been given limited research treatment. A great number of methods have been employed which makes the task of interpretation difficult. Worse, evaluation is hamstering of the great variety of stimuli and temporal interval used. In all cases stimuli are less complex, less "meaningful", and shorter than in our case, e.g., lists of words (Belmont, 1971; Rossi, 1971), number of disconnected pictures (Neimark, Slotnick & Ulrich, 1971), lists of selected items (Calfee, 1970) have been used not dramatic sequence. To make matters worse, there is not an accepted general summary of theory to fall back upon. Some studies (Belmont, 1968; Flugman, 1944; Hansen, 1965) claim that there is no consistent evidence that short-term memory developes with age. For long-term memory, Hansen (1965), who studied memory in a position of a picture in an array of momentarily expressed pictures, reports similar results. Others (Cambel, 1972; Rossi, 1971), however, with greatly different procedures, find that memory capacity improves with increasing age. Finally, it has been suggested (Mussen, 196) that the sources from which the perplexing problem of the variation in the quantity and quality of recall in children can spring include anxiety focussed attention, susceptibility to distraction, and motivation.

APPENDIX

Appendix A

A study run by Dr. Nelson and associates (1966) provides pilot data from which our hypotheses were formed. The study related the pars pro toto system (i.e., the whole system of a temporal pattern is represented by a single event or condition), to later attainment of various ideas of sequential ordering of events. The hypothesis tested was that pars pro toto responses are more characteristic of young children than those in later stages of development. To test these hypotheses film sequences were shown to 140 Ss of ages varying from 4 to 12 years of age. Ss were asked to describe what they had seen and how long was the film. Responses were coded in five ways: (a) no response, (b) pars pro toto, (c) sequence order, (d) multiple sequence, and (e) time estimation.

The experiment yielded encouraging results (Figure 5). It was found that the predominant feature of preschoolers were pars pro toto responses. By the time children were in third grade the most frequently made responses were sequential order and in fifth grade the multi-sequence order was achieved.

In addition to these "time indications" data, time estimation experiments were run under two conditions. Some children were shown 5 minute (short films SF) and some 20 minute (long split film LSF). Results are illustrated in Figure 5. From these results we see that time estimation is achieved only after children are about to perceive multi-sequential events.

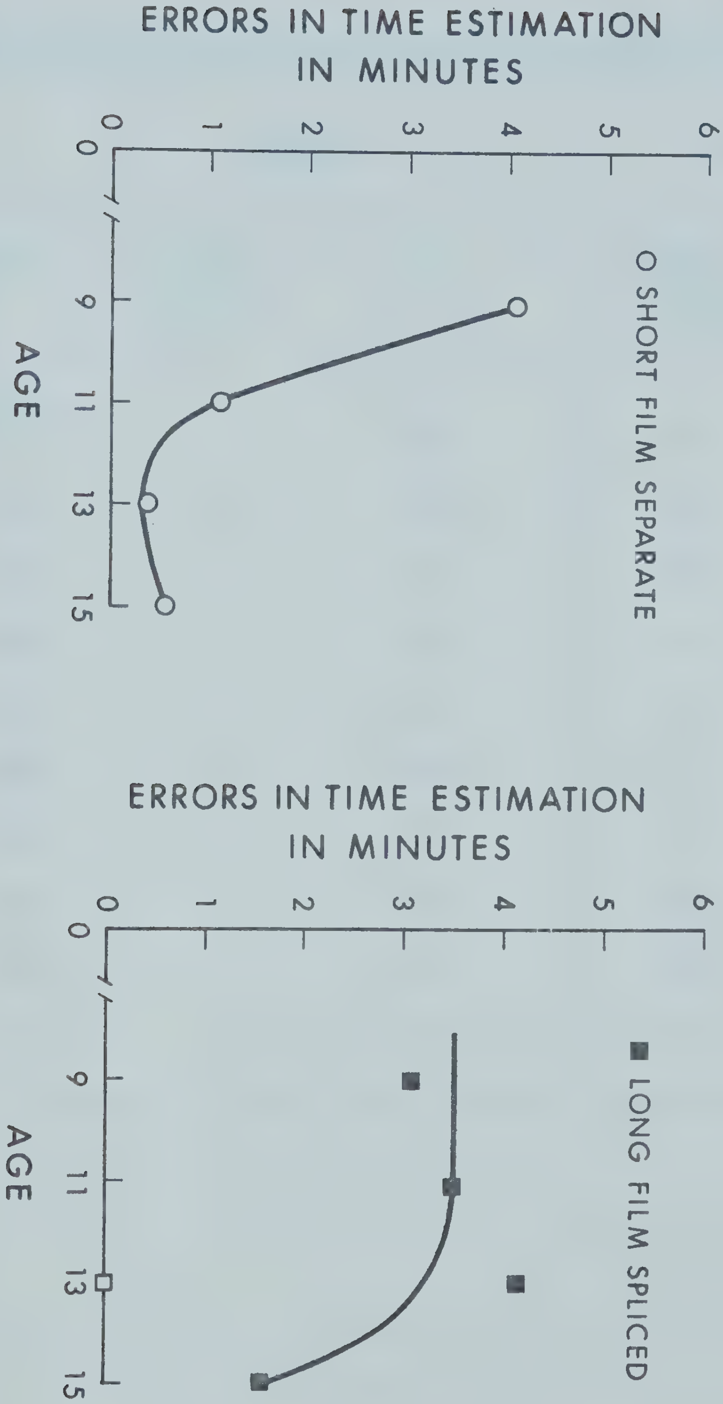

Figure 5: Variation of Time Error with Grade.

Appendix B

Table 1

Frequencies of Responses for Grades Analyzed by Chi-square Test.

	Condition 1		Condition 2	
The Compared Grades	Degrees of Freedom	Chi-Square	Degrees of Freedom	Chi-Square
Preschooler vs. 1st Grade	2	4.08	3	1.09
1st vs. 2nd	2	7.13*	3	4.52
2nd vs. 3rd	2	2.03	3	3.77
3rd vs. 4th	2	5.62	3	2.79
4th vs. 5th	2	5.36	3	5.77
5th vs. 6th	2	1.09	3	4.75
6th vs. 7th	2	0	3	2.40
7th vs. 8th	2	0	3	6.57
8th vs. 9th	2	0	3	5.56
9th vs. 10th	2	0	3	0

Appendix C

Table 2

Table of Means, Variances and Standard Deviations for the Time Estimation Error Data Obtained from the Short Film for Different Grades

Condition 1

Grades	Number Ss	Mean	Variance	Standard Deviation
1	25	12.7600	367.2734	19.1644
2	25	7.7600	119.0233	10.9098
3	25	8.0000	188.9167	13.7447
4	25	3.9200	4.0767	2.0191
5	25	3.6400	8.4900	2.9138
6	25	4.1200	65.2767	8.0794
7	25	1.2800	2.3767	1.5416
8	25	0.7600	1.1067	1.0520
9	25	0.7200	0.4600	0.6782
10	25	0.9200	0.6600	0.8124
Total	250	4.3880	87.1015	9.3328

Analysis of Variance for Time Estimation Data.

Source	SS	MS	df	F	p
Groups	.3591	399.06	9	5.27	> .01
Error	.1818	75.77	240	-	-

Appendix D

Table 3

Table of Means, Variances and Standard Deviations for Time Estimation Error Data Obtained from the Split Film for Different School Grades

Condition 2

Grades	Number of Ss	Mean	Variance	Standard Deviation
4	25	7.5200	29.9267	5.4705
5	25	4.6400	20.8233	4.5633
6	25	6.7200	13.2100	3.6346
7	25	5.6400	16.6567	4.0813
8	25	1.4400	3.0900	1.7578
9	25	2.4000	2.9167	1.7078
10	25	4.9200	9.0767	3.0128
Total	175	4.7543	17.2482	4.1531

Analysis of Variance for Time Estimation Data.

Source	SS	MS	df	F	*p*
Groups	.7216	120.27	6	8.80	$< .01$
Error	.2297	13.67	168	-	-